Weekly report no. 2 EIFEX ANT XXI/3 RV "Polarstern" 2 February 2004

Monitors stand in all laboratories and gathering places on this fine ship that provide continuous updates on her position, speed and, amongst various other data, also the number of the station the ship is either currently occupying, or going to occupy next. A "station" is oceanographer jargon for whenever a ship stops to carry out measurements, collect samples or both. On "normal" cruises the ship makes bee lines between stations whose posi--tions are fixed beforehand. But after finishing our first CTD transect, which showed no signs of an eddy, we did not know where the next station would be. For want of a number during the first half of last week, the captain wrote "Search for the eddy" in this box. We knew we were going to an eddy but we didn't know where it was. We hunted our quarry - an eddy of about 100 km diameter rotating in a clockwise direction - using sonar, the bat's and dolphin's organ of perception.

Polarstern´s sense organ is the Acoustic Doppler Current Profiler (ADCP) which emits high-frequency sounds that bounce back from tiny particles of plankton drifting in the water below the ship. The ADCP analyses these echoes and is able to estimate the velocity of the layers in which they are located. The acoustic information is converted into arrows pointing in the direction of the current at that point. Their length indicates current speeds. A separate sheet is printed for each depth layer for 6 layers down to 300 m depth. If we crossed an eddy, the plots of ADCP tracks would show bundles of arrows of equal length pointing in opposite directions, either adjacent to each other if we cut the flank, or up to 100 km apart if we crossed its centre. In the latter case there would be short arrows in between representing the eddy's calmer centre.

We were aided in our search by satellite images of sea surface height provided by altimeters mounted on two satellites. The images depict varia-tion in sea surface height of a few decimetres across many tens of kilome-tres. Eddies circling cold-water cores are about 20 –40 cm deeper in the middle than at the circumference because denser (colder) water occupies less volume than for the same weight of less dense (warmer) water. The colder the core water relative to its surroundings, the deeper the depression; conversely, eddies with warmer cores are raised in the centre by the same amount. Eddies arise when bands of fast currents meander into loops that eventually detach from the current which formed them and continue to spin on their own for a while, eventually slowing down and dissipating into the surrounding waters.

Why we need to grow our bloom in a clockwise eddy requires some background information on the properties of the Antarctic Circumpolar Current (ACC). This 1000 km broad ring of cold water, which encircles the continent and insulates its load of ice from the rest of the globe, is pushed eastward by the west wind belt. The ACC consists of several parallel, ca. 200 km broad bands of water that increase in temperature from south to north by about a degree per band and are separated by fast-flowing frontal jets of which the

Polar Front is the most prominent. These fronts meander either to the north or south and can hence shed eddies on either side. In doing so they trans--port water from one band into the other. The ACC surface waters are extremely rich in nutrients because they are being continuously replenished by deep water upwelling along its southern boundary. Whereas nitrate and phosphate concentrations remain high across the ACC, silica concentrations decrease markedly from north to south due to uptake by diatoms. By this time of the year, waters north of the Polar Front are depleted in silica. Since our bloom will
be dominated by diatoms, we need to carry out the experiment in a silica-rich eddy containing colder water from south of the Polar Front. Such an eddy will be spinning in a clockwise direction.

Since our first southward transect to 52°S showed no signs of the eddy we had selected from the altimeter images, we decided to rely for a while only on the ADCP, as this would allow us to steam at 13 knots (about 20 km/h) without interruption. A diagonal track to the northeast again yielded only eastward currents, so we laid another transect to cut through the area between the two tracks and this time found a band of strong currents flow--ing southwest. As an adjacent band of currents was flowing in the opposite direction, the physicists conjectured that this could represent the "umbilical cord" of an eddy in the process of detachment. The younger they are, the longer they can last, so we decided to invest some time in finding out whether it fulfilled all our requirements.

We spent the next days mapping the eddy and its surroundings with a series of north-south ADCP transects interspersed every 12 miles with short CTD stations. The picture that emerged by the end of last week confirmed the earlier prediction of the physicists This was a young eddy with an el-----lip---soid-shaped cold core 130 x 50 km in dimension extending well below 300m depth, clearly isolated from its surroundings and bounded to the north by the strong currents of the Polar Front. Silica concentrations were very high in the cold core indicating that this water mass had been dragged northward by the frontal jet south of the Polar Front. All the requirements were met, we had found our quarry. A cause for concern was the ellipsoidal shape which would gradually become rounded with time. What this would do to the fertilized patch was uncertain. One possibility was that the patch would be pulled out into a spiral and some of it might be lost to the surroundings. Pinpointing the area with the lowest current speeds and placing our patch on its centre seemed to be the safest course to ensure that our patch remained rounded. After a tight ADCP grid crisscrossing the surmised centre confirmed the most suitable site, we deployed a floating buoy attached to a drogue at 30 m depth and carried out our first full station of the cruise on Sunday afternoon. The station lasted till early Monday morning by which time the demands of all the groups on board had been met. Data collected during this station provide the initial conditions prior to fertilisation. We commenced fertilising the eddy’s centre on early Monday morning.

While the physicists were busy mapping the eddy, the chemists and bi---ol-o----gists had measured its surface properties and the distribution of plankton. High CO_2 and nutrient concentrations in the core indicated that not much biological activity had taken place in it. Iron concentrations were very low and so were those of phytoplankton (the unicellular algae comprising the plants of the plankton). The low chlorophyll concentrations (0.2 mg Chl./m3) in the cold core contrasted strongly with the much higher values in the Polar Front (1.2 mg Chl/m3). The frontal plankton had probably received a "shot of iron" in the recent past that had not reached their southern counterparts. The source of the iron is not known but it could have come from deeper water upwelling along the front, from dust settling locally in rain, or from melting icebergs. We had encountered 5 stately icebergs in the region and they are known sources of iron. One of the stations happened to be so close to an iceberg that one of the new--com--ers to the Southern Ocean asked if we had stopped the ship to let everybody appreciate its sweeping form, the breakers rushing up its smooth sides and its soft shades of grey, white and blue.

The weather has not been a problem so far; on the contrary, the stiff breeze blowing since a few days serves to ensure that the iron solution will be well mixed in the course of the next few days without incon-ve------nienc-ing anybody or restricting any activity. We have now entered the second lap of the cruise, and are looking forward to further develop-ments. Trial flights of the helicopter-based LIDAR sensor which tracks chlorophyll concentrations have proven successful, so we are confident that we will be able to map the patch rapidly once the plankton start growing.

With our best wishes from an excited ship,
Victor Smetacek